

# OPPORTUNITIES IN SOLAR SYSTEM EXPLORATION

Susan M. Niebur<sup>1</sup>

NASA Headquarters, 300 E Street SW, Washington, D.C. 20546-0001 USA

## ABSTRACT

NASA's Office of Space Science launches several space missions a year and is always looking for technology development that will enable return of new and interesting data. The Division of Solar System Exploration has several technology development programs that solicit proposals for new or improved instruments, including thermal detectors. The Planetary Instrument Definition and Development Program solicits ideas for low mass, low power instruments that are in the earliest stages of development and are intended for use on future Discovery, Mars, or New Frontiers missions. These instrument concepts would be classified as Technology Readiness Level (TRL) 1-3. The Mars Instrument Development Program takes instruments from a moderately advanced stage of development to flight test (TRL 4-6) and is intended for development of instruments to be used on missions to Mars. Astrobiology Science and Technology Instrument Development and Mission Concept Studies may be at any stage of instrument design and development (TRL 1-6) that may be of use for future Astrobiology investigations. The High Capability Instruments for Planetary Exploration Program, which focuses on earlier stages of instrument development (TRL 1-3), and the High Capability Instruments Risk Retirement Program, which further develops more mature instruments (TRL 4+), seek instruments that will be used in Project Prometheus, which does not have the low power and mass constraints of the other Solar System Exploration programs. This paper will give a brief overview of proposal opportunities for technology development and complete missions to explore the Solar System. For the latest information on any of these programs, please refer to the current version of the official NASA documents cited herein.

## INTRODUCTION

NASA's Office of Space Science (OSS) launches several space missions a year and is always looking for technology development that will enable return of new and interesting data. The Division of Solar System Exploration has several technology development programs, for various stages of development or scientific goal, that solicit proposals for new or improved thermal detectors. These programs include the Planetary Instrument Definition and Development Program (PIDDP), the Mars Instrument Development Program (MIDP), Astrobiology Science and Technology Instrument Development and Mission Concept Studies (ASTID), the High Capability Instruments for Planetary Exploration Program (HiCap), and the High Capability Instruments Risk Retirement Program. The goal of these programs is to produce advanced technologies to be used on missions proposed to the Discovery Program, New Frontiers Program, Mars Program, or Project Prometheus, major avenues for Solar System Exploration.

Stepwise development of an instrument from concept to flight demonstrator may be described in many terms; NASA categorizes technology development stages into Technology Readiness Levels (TRLs) that range from 1 to 9. TRL 1 research is at the most basic level, before the technology concept and/or application are fully formulated (which is TRL 2). TRL 3 instruments would develop proof-of-concept. TRL 4 and 5 would be granted to instrument components that are validated in the laboratory or simulated operating environment, respectively. TRL 6 indicates that the system or subsystem model or prototype has been demonstrated in the space environment or appropriate ground-based environment. TRL 7 is given to

---

Contact information for S. M. Niebur: Email: [Susan.M.Niebur@nasa.gov](mailto:Susan.M.Niebur@nasa.gov), phone (202) 358-0745, fax (202) 358-3097

instruments which have had a successful system prototype demonstration in a space environment. TRL 8 instruments are flight qualified, through tests and demonstration(s). TRL 9 instruments have been flight proven, through successful mission operations. Further discussion of these technology readiness levels can be found in the Office of Space Science Management Handbook<sup>1</sup>, which is freely available on the Web from the NASA OSS home page.

## **DETECTOR DEVELOPMENT OPPORTUNITIES**

There are currently four major opportunities for thermal detector development through the NASA OSS Division of Solar System Exploration (SSE). Each of these research programs solicits new instrument development through the NASA Research Announcement "Research Opportunities in Space Science" (ROSS-NRA)<sup>2</sup>. The ROSS-2003 NRA includes open solicitations for the PIDDP, MIDP, and ASTID. This summer, an amendment to the ROSS-2003 will be issued, soliciting high capability instruments for planetary exploration. Future new opportunities, such as the planned risk retirement program for these high capability instruments, will be released through future ROSS NRAs. PIDDP, MIDP, ASTID, and HiCap investigations are all selected through open competition and peer review. Each program focuses on funding investigations at a certain TRL and with a distinct planetary focus. The following discussion is meant to be a general guide to the programs, but more, up-to-date information, may always be found in the most current ROSS NRA, also available from the NASA OSS home page on the Web.

### **PIDDP**

Completely new instrumentation for Solar System Exploration missions is often initiated under a PIDDP grant. Instrument definition and development studies may incorporate feasibility studies, conceptual design, and laboratory breadboarding of instruments or particularly risky components of instruments. Although the evaluation criteria include the applicability of the instrument to potential future Discovery, Mars, or New Frontiers missions that achieve Solar System Exploration and/or Origins of Solar Systems goals (as stated in the NASA OSS Strategic Plan<sup>3</sup>), specific missions do not have to be identified. In fact, many missions have incorporated new technologies developed through PIDDP, and look to the program for new technology that has been developed through TRL 3. Development that has already achieved TRL 3 may be proposed through MIDP, ASTID, and HiCap.

### **MIDP**

MIDP will support instrument development from the breadboard validation or laboratory demonstration phase (TRL 4) to testing under realistic conditions (TRL 6) for those instruments specifically suited for the characterization of the Mars surface. Instruments proposed to MIDP must demonstrate a moderately advanced stage of development. This level of maturity is expected to be achieved after the completion of a PIDDP grant or other similar program support. Successful proposals will include a complete discussion of the applicability of the proposed instrument to a future Mars mission, as discussed specifically in the annual ROSS NRA and the NASA OSS Strategic Plan<sup>3</sup>.

### **ASTID**

ASTID program provides grants to further research and development of instrumentation capabilities that will help meet Astrobiology science requirements on future space flight missions. These requirements, like the Mars exploration requirements, are discussed in the NASA OSS Strategic Plan<sup>3</sup>. Instruments designed to open a new study of Astrobiology are also candidates for ASTID funding. This program allows development of instruments or concepts that could be classified as TRL 1-6.

### **HiCap**

HiCap is designed to develop a new category of instruments meant to be used on missions using nuclear electric power and propulsion (NEPP). These missions are part of NASA's new Project Prometheus Program. NEPP provides capabilities for instruments far beyond those of other missions. These instrument capabilities include electrical power up to 10-100 kW, data rates ranging from 10-100 Megabits/sec for acquisition and transmission to Earth, high duty cycles, and long observation periods at their targets.

Project Prometheus missions will be launched on larger launch vehicles, allowing less stringent payload mass limitations than in the typical Solar System Exploration launch. With these capabilities, active instruments and EOS-type instruments are feasible for planetary exploration.

This class of high capability instruments is not yet well-defined; the space science community has a rare opportunity to begin development on heretofore unrealizable instruments. The first HiCap solicitation will be released as an amendment to the ROSS-2003 NRA in summer 2003 and will call for proposals at any TRL. In FY06, NASA will release a solicitation for a Risk Retirement Program for the high capability instruments. This risk retirement program will focus on higher TRLs, and HiCap will then focus on lower TRL concepts. Advanced detector research is welcome in these programs, as it is in PIDDP, MIDP, and ASTID.

## MISSION PROPOSAL OPPORTUNITIES

The area of Solar System Exploration is expanding, with opportunities this year to propose several types of planetary system(s) science investigation. This year, the Discovery Program will release its fifth Announcement of Opportunity (AO) to propose complete missions. Two sample return missions, Stardust and Genesis, are currently in operation, and four Discovery missions are in formulation or development. The New Frontiers Program, a new proposal opportunity modeled on the successful Discovery Program, will release its first AO this summer. Project Prometheus, a new program to develop nuclear electric power and propulsion technology intended to enable a new class of high-power, high-capability missions, is another new opportunity to propose investigations. All three classes of mission encourage the inclusion of new technology, as well as a commitment to provide data to the Planetary Data System, any samples to the NASA Curatorial Facility at Johnson Space Center, and programs for education and public outreach.

**Discovery:** The Discovery Program<sup>4</sup> was established in 1994 to provide regular opportunities to launch planetary missions. Small planetary system(s) science investigations that require free-flying missions launched on the space shuttle or an expendable launch vehicle are proposed and evaluated by teams of scientists, engineers, and other technical personnel. The proposal teams are formed and led by a single scientific Principal Investigator. The teams may include participation from a number of scientific Co-Investigators, instrument teams, the engineering project team, and industry partners. There have been six Discovery missions launched to date: NEAR, Lunar Prospector, Pathfinder, Stardust, Genesis, and Contour. The next opportunity to propose a Discovery mission is planned to occur in Fiscal Year 2004. Discovery missions are cost-capped missions, with a current total NASA Office of Space Science (OSS) cost of up to \$350 M. Missions typically launch three years after confirmation, within six years after proposal.

**New Frontiers:** The New Frontiers Program<sup>5</sup> has recently been introduced in order to allow larger, more capable PI-led missions to explore the Solar System and/or return samples for study. The National Academy Decadal Survey<sup>6</sup> has recommended five medium-class mission investigations: Comet Surface Sample Return, South Pole Aitken Basin Sample Return, Venus *In Situ* Explorer, Jupiter Polar Orbiter with Probes, and a Kuiper Belt/Pluto mission. The first New Frontiers mission will be New Horizons, a mission to Pluto and the Kuiper Belt. The other four investigations will comprise the possible target set for mission proposals in 2003. The NASA OSS cost for these missions can be up to \$650 M. These missions may therefore employ radioactive power sources and Evolved Expendable Launch Vehicles, such as the Atlas V or Delta IV, enabling an expanded opportunity to explore the solar system, including the return of samples. Missions should launch within four years of confirmation. These missions will also incorporate technology developed under PIDDP, where possible.

**Project Prometheus:** Project Prometheus, new in 2003, is designed to develop nuclear electric power and propulsion technology to allow a new era of scientific investigation with capabilities far beyond those available today. These missions will employ on-board nuclear fission reactors and high power ion engines to provide revolutionary capabilities such as high power levels for instruments (10 – 45 kW), high data

rates for acquisition and telecom (10 Mbps), large payload mass, multi-target rendezvous and orbits, and extended observation time. The first Project Prometheus mission is the Jupiter Icy Moons Orbiter (JIMO). A Science Definition Team is currently formulating science objectives for the mission, and JIMO instrument selection will occur after these objectives are finalized. Since Project Prometheus is planned as a recurring mission line, NASA will soon release a request for studies of future high capability missions that will also utilize new instruments developed under HiCap and the other technology development programs. A list of possible future Project Prometheus missions includes, but is not limited to, Titan explorer, comet chaser, interstellar probe, and Neptune/Triton missions.

## CONCLUSION

**Conclusion:** The instrument development programs PIDDP, MIDP, ASTID, and HiCap offer multiple opportunities to obtain NASA OSS funding for technology development, including detector research, that will be incorporated into future mission proposals for Solar System Exploration. The Discovery, New Frontiers, and Project Prometheus mission lines provide opportunities for small, medium, and high-powered missions that will explore the Solar System and return valuable data and extraterrestrial samples. The Office of Space Science welcomes your proposals for technology development and flight through these and other opportunities.

## REFERENCES

1. Office of Space Science Management Handbook, 2002.
2. NASA Research Announcement: Research Opportunities in Space Science, 2003.
3. NASA Office of Space Science Strategic Plan, 2003.
4. NASA Announcement of Opportunity: Discovery Missions and Missions of Opportunity – 2003 (in preparation).
5. NASA Announcement of Opportunity: New Frontiers Missions and Missions of Opportunity – 2003 (in preparation).
6. *New Frontiers in the Solar System*, National Research Council, 2002.